A BIOLOGICAL EVALUATION OF WHITE PINE BLISTER RUST ON THE SIERRA NATIONAL FOREST

Report No. 82-44

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John Kliejunas, Plant Pathologist

ABSTRACT

A white pine blister rust incidence and impact survey was conducted on the Sierra National Forest. Previously unreported blister rust infection centers were found at Laurel Creek on the Kings River Ranger District, and at California Creek, Willow Creek Ditch, Willow Creek and Grey's Fork Creek on the Bass Lake Ranger District. Of 226 sugar pines examined at the five sites, 27% were infected. Approximate boundaries of the rust in the Dinkey Creek area were delineated and infection centers at Forked Meadow Creek and Duff Creek were intensively examined to determine characteristics of infection. Thirty-eight percent of the trees at Forked Meadow Creek and 22% of the trees at Duff Creek were lethally infected. Canker incidence in all tree diameter classes generally decreased from stream bottom to upper slope at Duff Creek. Although 1976 was a peak year for rust infection, cankers were initiated every year from 1972 through 1979. Management alternatives discussed include removal of infected trees during sanitation and precommercial thinnings, pruning, and strategies for regenerating sugar pine on low, moderate, and high hazard sites.

USDA, FOREST SERVICE, PACIFIC SOUTHWEST REGION
State and Private Forestry, Forest Pest Management
630 Sansome Street, San Francisco, California 94111

INTRODUCTION

White pine blister rust, caused by the fungus Cronartium ribicola, has advanced steadily southward in California since it first entered the State near the Oregon border in 1929. By 1938 infection centers had become established on sugar pine in the northern and central parts of the Sierra Nevada, and in 1944 several infection centers became established near Dodge Ridge on the Stanislaus National Forest. Because the disease is largely dependent on cool, moist weather for successful infection, it was thought that unfavorable climatic conditions would limit the spread and impact of the disease into the more southern Sierra and Sequoia National Forests. In 1969, streamside surveys found the rust at Providence Creek in the Dinkey Creek area of the Sierra National Forest. The center originated in 1961 and intensified in 1964 and 1967. In 1972 and 1973, sugar pines at Forked Meadow, Exchequer, Duff, Bear Meadow and Dinkey Meadow creeks in the Dinkey Creek area were reported as infected. No formal rust detection surveys were made on the Forest between 1974 and 1981. Recent reports of increased rust incidence in the Dinkey Creek area and one 1981 report of rust at Soquel Meadow on the Bass Lake Ranger District have renewed interest and concern.

Currently, sugar pine is the principal species used for artificial regeneration in the 5500 through 6500 foot seed zones on the Sierra National Forest. The Forest expects to maintain sugar pine as a significant component of the mixed conifer type. White pine blister rust may interfere with these management plans.

In June 1982, the Forest Pest Management Staff conducted an incidence and impact survey on the Sierra National Forest in order to determine 1) the rate of new blister rust establishment as determined by scouting for the rust in locations reportedly rust-free in 1972, and 2) the intensification of, rate of spread from, and the levels of damage caused by white pine blister rust in known infection centers in the vicinity of the Dinkey Creek area. The results of these surveys are for use to 1) provide information to the Forest and the Region on locations and impact of the rust disease, 2) to develop strategies for managing the existing and future sugar pine resource, and 3) to determine the need for developing rust resistant sugar pine for the Sierra National Forest.

BIOLOGY OF THE PEST

White pine blister rust is caused by the fungus Cronartium ribicola, an obligate parasite that attacks sugar and western white pines and several species of Ribes in California. The fungus needs two hosts to survive, spending part of its life on 5-needled pines and the other on Ribes. Infection of pines may result in branch mortality, top kill, and tree mortality.

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Active branch cankers enlarge annually as the fungus invades additional tissues and moves toward the bole. Branch cankers within 24 inches of the bole will eventually reach the bole and form cankers. Bole cankers that girdle the stem kill the tree above the canker. Cankers whose closest margins are more than 24 inches from the bole will usually die out before reaching the bole, and only branch flagging will occur.

Environmental conditions are critical for successful infection and limit the disease in most years. Abundant moisture and cool temperatures favor infection of both hosts, and must coincide with spore dispersal for infection to occur. At least 48 hours with a saturated atmosphere and a temperature near 20°C are needed for infection of pines. In California, the sites where these conditions frequently occur are usually in cool moist areas such as stream bottoms or around meadows. When these years of favorable environmental conditions (wave years) occur, high incidence of infection can result. Wave years have occurred in northern and central California at approximately ten-year intervals in the past. As one moves to less favorable sites for rust, the frequency of wave years decreases.

INCIDENCE SURVEY

PROCEDURE

Streams known to have sugar pine, based on 1965 through 1972 blister rust surveys, were marked on a Forest map, and those streams that were crossed by an accessible road or that were within two chains of an accessible road were selected and a portion of them systematically sampled. The number of stream locations actually sampled (16) was limited by the 8 man-days available for the survey. At each sample point, a one-chain-wide strip was examined on each side of the stream for four chains upstream and four chains downstream. Information, including sugar pine diameter class, presence or absence of rust infection, and, if infected, canker information, including canker class and year of wood infected, were recorded. (See Appendix for definitions of tree diameter classes and blister rust canker classes.)

RESULTS AND DISCUSSION

Previously-unreported blister rust infection centers were found at five of the 16 stream locations surveyed (Fig. 1). These included one at Laurel Creek (T.10 S., R.26 E., sec. 22) on the Kings River Ranger District; and four on the Bass Lake Ranger District, at California Creek

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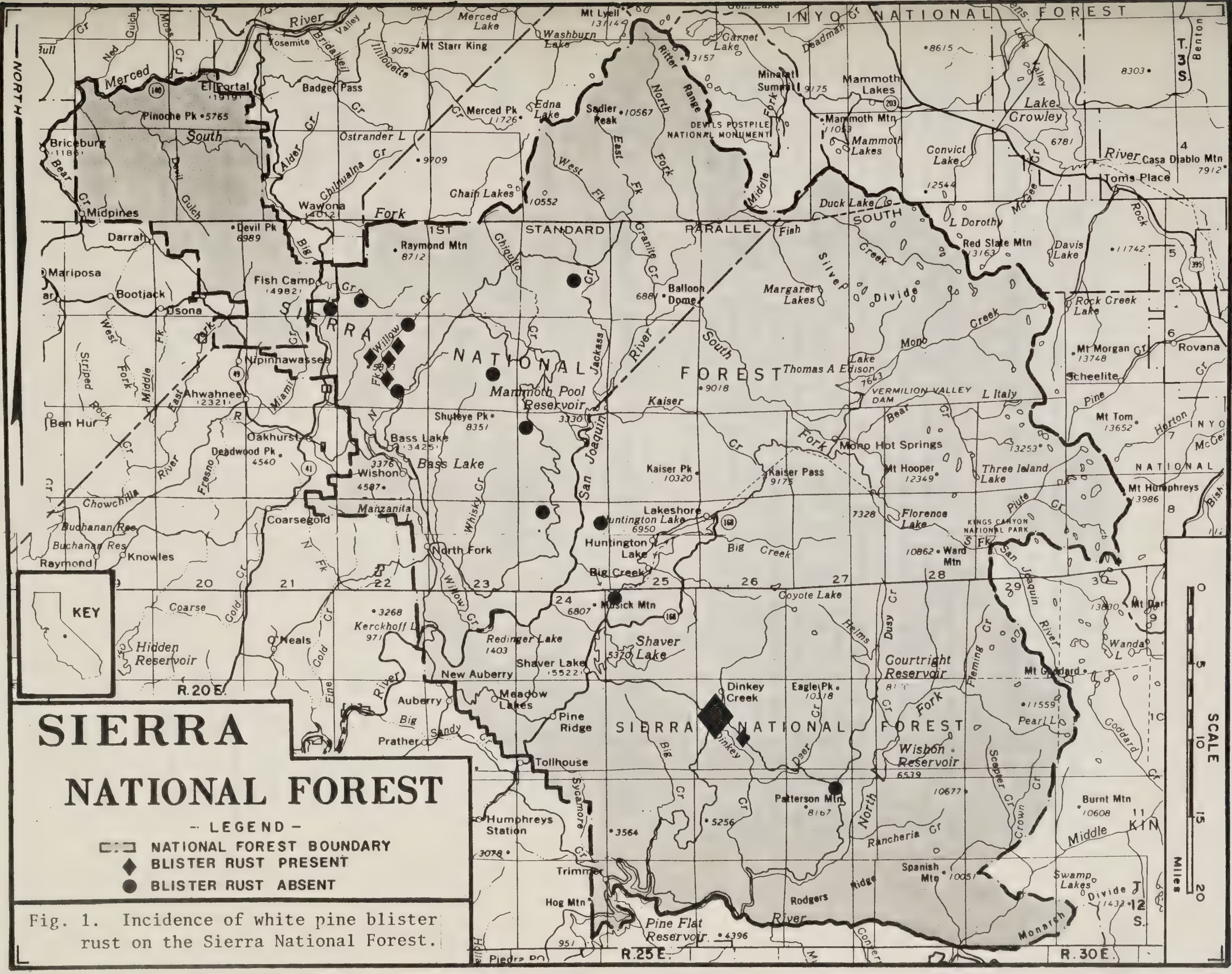

Fig. 1. Incidence of white pine blister rust on the Sierra National Forest.

(T.6 S., R.22 E., sec. 17), Willow Creek Ditch (T.6 S., R.22 E., sec. 9), Willow Creek (T.6 S., R.22 E., sec. 16), and Grey's Fork Creek (T.6 S., R.22 E., sec. 22). The Laurel Creek location was near the Dinkey Creek centers reported in 1972 and the four locations on the Bass Lake District were in the vicinity of the Soquel Meadow infection site first reported in 1981.

Frequencies and characteristics of rust infections are presented in Tables 1 and 2. Of 226 sugar pines examined at the five sites, 27% were infected. Forty of the 60 infected trees were lethally infected. Lethally infected trees are those with nonprunable bole cankers, lethal nonprunable branch cankers, and/or lethal branch cankers (see Appendix for definitions). The remaining 20 trees could be pruned free of existing infections if pruning were done in the first 16 feet of the main stem and in the lower two-thirds of the live crown. Infections generally occurred in trees of all diameter classes (Table 3). The percentage of cankered trees in each diameter class varied from 17% of the trees 26 inches dbh (diameter at breast height) or larger to 38% of the trees from 1.0 to 5.9 inches dbh.

TABLE 1. Number and percent of sugar pines infected with white pine blister rust at five locations on the Sierra National Forest.

LOCATION	NUMBER OF TREES EXAMINED	INFECTED NO.	INFECTED (%)	LETHALLY INFECTED NO.	LETHALLY INFECTED (%)
LAUREL CREEK	37	13	(35)	7	(19)
CALIFORNIA CREEK	37	10	(27)	6	(16)
WILLOW CREEK DITCH	71	7	(10)	3	(4)
WILLOW CREEK	35	23	(66)	21	(60)
GREY'S FORK CREEK	46	7	(15)	3	(15)
TOTAL	226	60	(27)	40	(18)

TABLE 2. White pine blister rust infections, by canker class, at five locations on the Sierra National Forest.

LOCATION	BOLE CANKERS PRUNABLE	BOLE CANKERS NON PRUNABLE	BRANCH CANKERS NON LETHAL	BRANCH CANKERS LETHAL PRUNABLE	BRANCH CANKERS LETHAL NONPRUNABLE	BRANCH CANKERS LETHAL
LAUREL CREEK	0	1	27	9	3	6
CALIFORNIA CR.	0	4	16	9	4	2
WILLOW CR. DITCH	0	2	3	7	0	2
WILLOW CREEK	1	9	41	19	16	30
GREY'S FORK CR.	0	2	8	6	2	0
TOTAL	1	18	95	50	25	40

TABLE 3. Number of sugar pines infected with blister rust, by tree diameter class, at five locations on the Sierra National Forest.

LOCATION	TREE DIAMETER CLASS[1] 1	2	3	4	5	6
LAUREL CREEK	5/20[2]	4/10	2/3	1/3	1/1	0/0
CALIFORNIA CREEK	4/13	5/8	1/7	0/1	0/4	0/4
WILLOW CREEK DITCH	3/31	3/29	0/7	1/3	0/0	1/1
WILLOW CREEK	6/12	13/17	3/5	1/1	0/0	0/0
GREY'S FORK CREEK	1/28	1/5	2/6	2/6	0/0	0/1
TOTAL	19/104	26/69	8/28	5/14	1/5	1/6
PERCENT INFECTED	18%	38%	29%	36%	20%	17%

[1] 1 = <1.0" dbh; 2 = 1.0 - 5.9"; 3 = 6.0 - 11.9"; 4 = 12.0 - 17.9"; 5 = 18.0 - 25.9"; 6 = 26.0" +

[2] Number of trees infected/total number of trees.

Blister rust infections frequently occur in "wave years" -- years especially favorable for infection because of favorable microclimatic conditions during the fall when spores are dispersed to pine. No wave year patterns were evident at the five locations (Table 4). Aging of 56 cankers, by determining year of wood infected, indicated that infection occurred essentially every year at the five locations from 1971 through 1978. Although 1976 was considered a wave year in northern California, and the largest number of cankers at the five locations were initiated in that year, cankers were initiated in other years as well. Infections occurring in 1971 are difficult to age now because in many cases the point of entry of the rust is gone, and infections occurring in 1979 or later would be barely visible or not visible at all at the time of this survey in 1982. These data on year of infection suggest that a microclimate favorable for infection occurs most years at the locations surveyed. Therefore, these locations should be considered high hazard sites, and sugar pines not resistant to the rust should not be planted.

Establishment and spread of the rust on the four creeks near Soquel Meadow has apparently occurred over the last decade. A more intensive survey is needed to determine more precisely the extent and impact of blister rust in that area. Infections at Laurel Creek probably spread from the Dinkey Creek area. Other areas of the Forest could likewise become infested. Continued surveillance for the rust is necessary on portions of the Forest not surveyed, and any new locations should be reported to Forest Pest Management and recorded by the District, preferably on stand record cards.

TABLE 4. Number of blister rust cankers by age of oldest canker at five locations on the Sierra National Forest.

LOCATION	YEAR OF WOOD INFECTED, OLDEST CANKER							
	1971	1972	1973	1974	1975	1976	1977	1978
LAUREL CREEK	1[1]	3	2	2	2	1	0	0
CALIFORNIA CREEK	1	3	0	3	0	2	0	0
WILLOW DITCH CREEK	0	1	0	1	1	1	2	1
WILLOW CREEK	1	0	2	1	6	6	5	1
GREY'S FORK CREEK	0	2	2	0	0	2	1	0
TOTAL	3	9	6	7	9	12	8	2

[1]Number of cankers.

IMPACT SURVEY

PROCEDURE

A survey of the six blister rust centers identified on the 1972 survey maps of the Dinkey Creek area (Exchequer, Forked Meadow, Dinkey Meadow, Duff, Bear Meadow, and Providence Creeks) was conducted in June of 1982. Because of extensive spread of the rust from the 1972 boundaries and the presence of private lands within the Forest boundary, exact current margins of infection centers could not be determined for comparison with 1972 boundaries. Instead, approximate current limits of the rust in the Dinkey Creek area were determined by traversing the area in the vicinity of the six creeks on foot and by vehicle. In addition, two sites -- Forked Meadow and Duff Creek -- were examined intensively to determine characteristics of infection.

The Forked Meadow and Duff Creek sites were examined as follows:

1. The approximate limits of infection -- upstream and downstream, and upslope on both sides of the streams -- were determined.

2. One-chain-wide strips, perpendicular to the stream bottom, were examined from ridgetop to ridgetop at 10-chain intervals. Each strip was terminated when no rust was found for two chains.

3. Data including tree diameter class, presence of infection, classes of bole and branch cankers (see Appendix), and year of wood infected were recorded for each sugar pine encountered on the strips. At Forked Meadow, data was taken from 12.7 acres of an area of approximately 160 acres. At Duff Creek, data was taken from 6.1 acres of an area of approximately 80 acres.

RESULTS AND DISCUSSION

Present Boundaries. White pine blister rust in the Dinkey Creek area has spread significantly and rapidly in the decade since the 1972 streamside survey (Fig. 2). Current boundaries are approximate, but the rust is now present throughout much of the area. The spread apparently occurred from pines along stream bottoms that were infected in 1972. Although numerous current infections are associated with favorable microclimatic conditions along streams and meadows, the rust is also present in upland sites such as the road over Dinkey Mountain from Ross Crossing to Dinkey Meadow Creek.

The factors limiting the current boundaries of the rust were not determined. Current boundaries may be more a result of insufficient time for spread rather than unfavorable climatic, topographic or genetic conditions.

Canker Incidence, by Type and Tree Diameter Class. Seventy-seven percent of the sugar pines at Forked Meadow and 38% of the sugar pines at Duff Creek had one or more blister rust cankers. These figures are equivalent to 10 of 13 sugar pine infected per acre at Forked Meadow and 19 of 51 sugar pine infected per acre at Duff Creek. Characteristics of

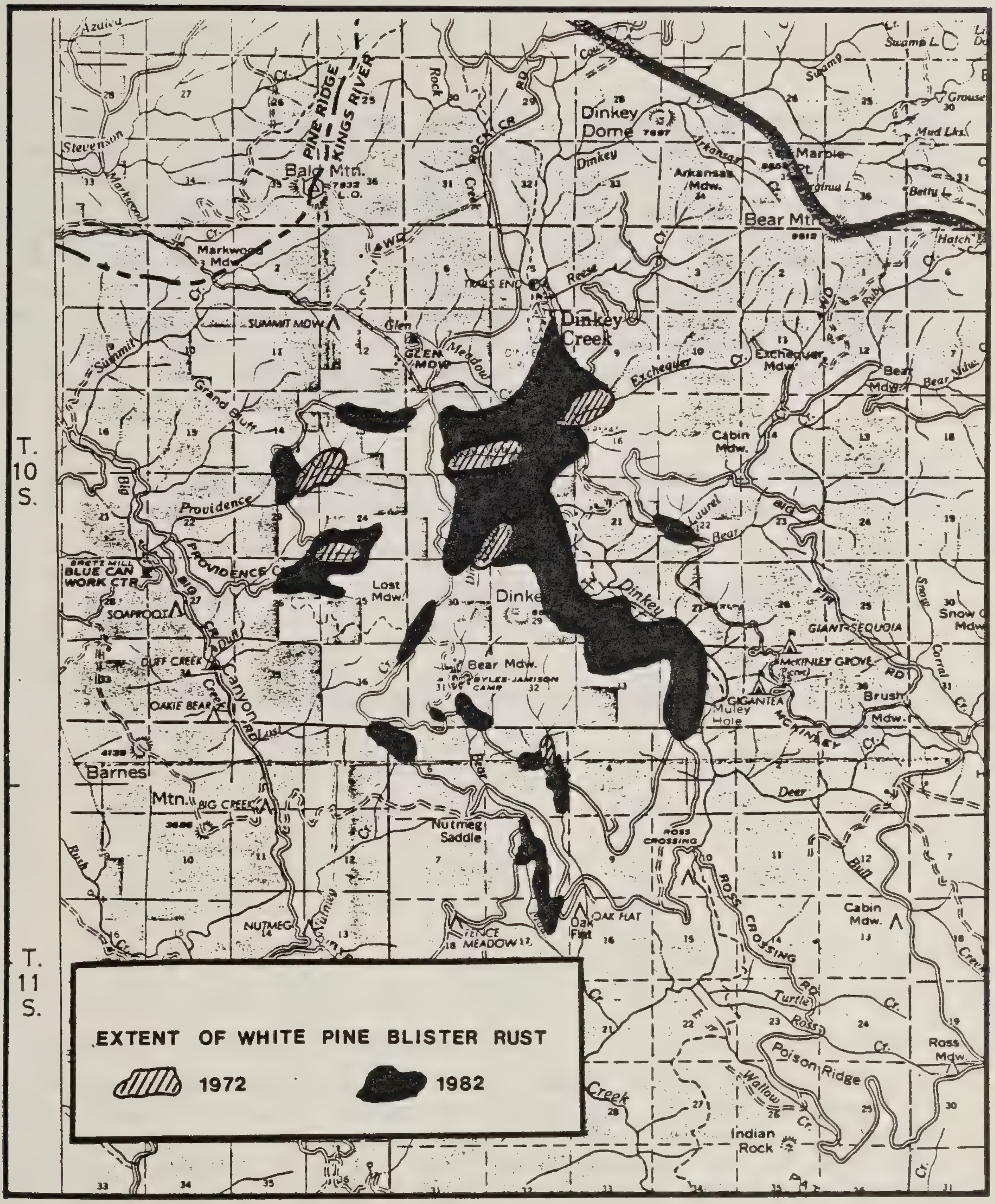

FIGURE 2. Incidence of white pine blister rust in the Dinkey Creek area, Sierra National Forest.

cankers recorded at Forked Meadow and Duff Creek are presented in Table 5. Some trees at Forked Meadow had more than 300 nonlethal branch cankers and one tree at Duff Creek had 200 nonlethal branch cankers. Differences in frequency of infected trees between the two sites may reflect differences in topography. The Forked Meadow area rises gradually from the stream bottom to indefinite ridge tops while the topography at Duff Creek is much more abrupt. The actual numbers of cankers of each category in Table 5 should be interpreted with caution. For example, even though a tree may have one or more prunable bole and branch cankers, it may also have several lethal nonprunable or lethal branch cankers and therefore be lethally infected.

TABLE 5. Characteristics of blister rust cankers recorded at Forked Meadow Creek and Duff Creek on the Sierra National Forest.

LOCATION	NUMBER OF TREES		BOLE CANKERS		BRANCH CANKERS			
	TOTAL	INFECTED	PRUNABLE	NON PRUNABLE	NON LETHAL	LETHAL PRUNABLE	LETHAL NON PRUNABLE	LETHAL
FORKED MEADOW	166	128	26	48	1944	305	154	77
DUFF CREEK	310	117	27	51	595	478	140	118
TOTAL	476	245	53	99	2539	783	294	195

A more accurate reflection of the actual impact of the disease is presented in Figures 3 and 4, where the number and percent of trees lethally infected, by tree diameter class, at each location are presented graphically. Lethally infected trees are those with one or more nonprunable bole cankers, lethal nonprunable branch cankers or lethal branch cankers.

Thirty-eight percent of the trees at Forked Meadow Creek (64 of 166) and 22% of the trees at Duff Creek (69 of 310) were lethally infected. These lethally infected trees will eventually be girdled and killed by the rust. However, not all lethally infected trees will die immediately. Data collected by Byler and Parmeter[1] in the northern Sierra

[1]Byler, James W., and John R. Parmeter, Jr. 1979. An evaluation of white pine blister rust in the Sierra Nevada. USDA Forest Service, Pacific Southwest Region. Report No. 79-3. 19 p.

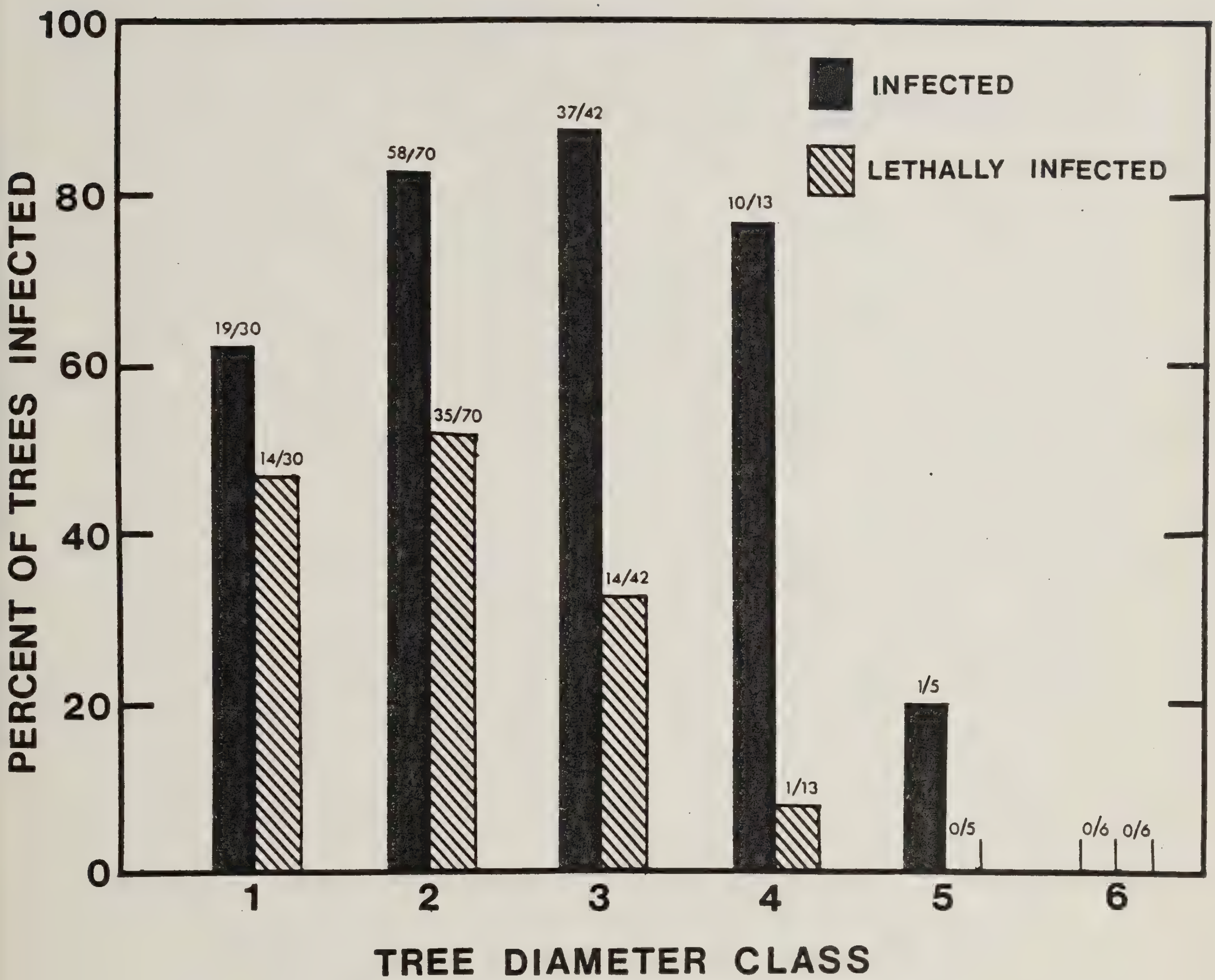

FIGURE 3. Percent of sugar pine infected and lethally infected, by tree diameter class, at Forked Meadow Creek. The numbers above each bar are the number of trees in that category/total number of trees. Tree diameter classes are 1 = less than 1 inch dbh, 2= 1.0 -5.9 inches, 3 = 6.0 - 11.9 inches, 4 = 12.0 - 17.9 inches, 5 = 18.0 - 25.9 inches, and 6 = 26 inches dbh and greater.

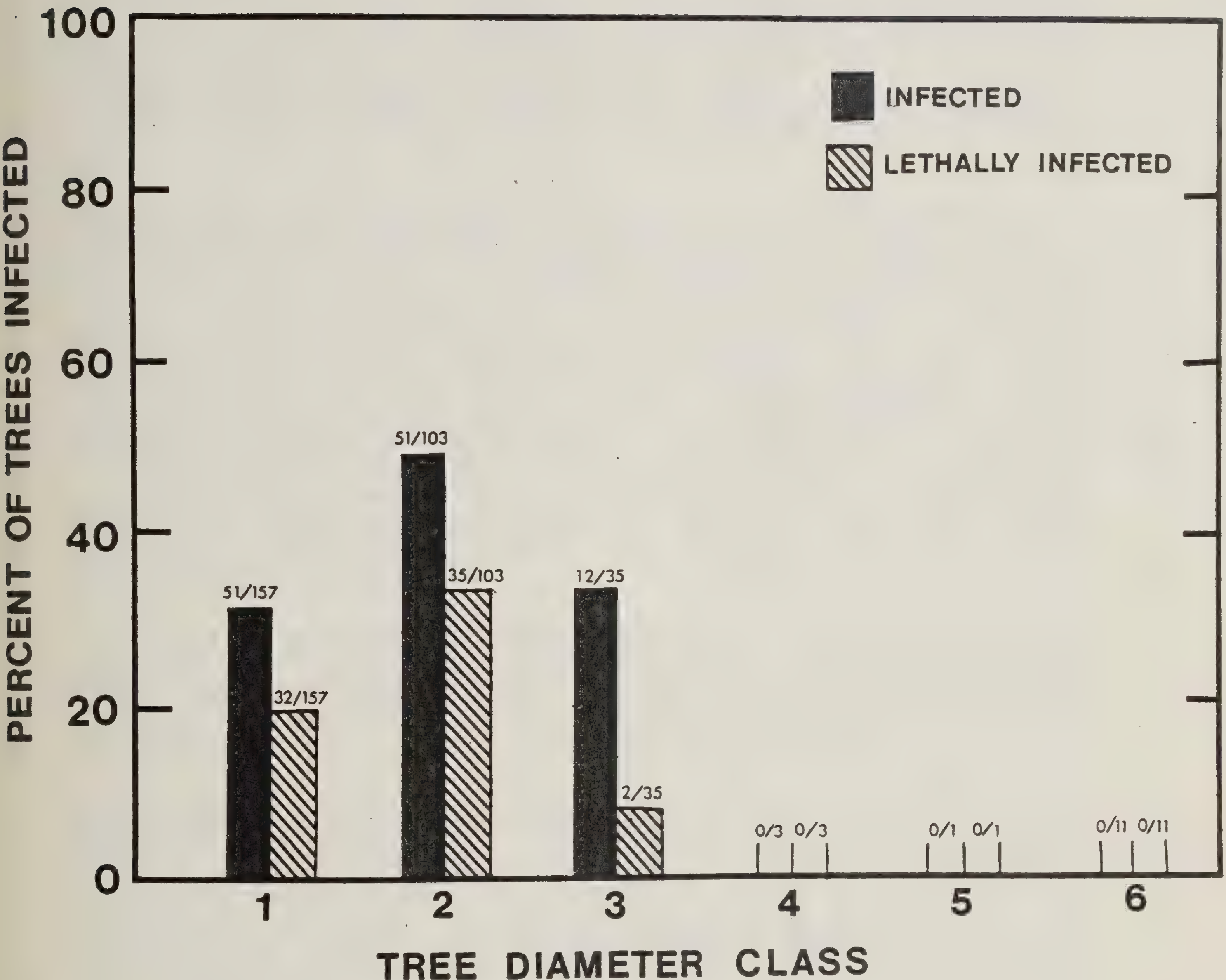

FIGURE 4. Percent of sugar pine infected and lethally infected, by tree diameter class, at Duff Creek. The numbers above each bar are the number of trees in that category/total number of trees. Tree diameter classes are 1 = less than 1 inch dbh, 2 = 1.0 - 5.9 inches, 3 = 6.0 - 11.9 inches, 4 = 12.0 - 17.9 inches, 5 = 18.0 - 25.9 inches, and 6 = 26 inches dbh and greater.

Nevada (Lassen, Plumas, Tahoe, and Eldorado National Forests) indicated that infected trees 7 inches dbh or larger are expected to live until they reach 12 inches dbh. Therefore, if their data are applicable to the Dinkey Creek area, about 49 trees in the sampled area (4 trees/acre) at Forked Meadow and about 67 trees in the sampled area (11 trees/acre) at Duff Creek will die before reaching a merchantable size of 12 inches dbh.

Canker Incidence, by Topography. Observations in northern California forests, supported by field studies, suggest that the levels of infection along stream bottoms are generally higher than in upland sites. Data for canker incidence at six stream bottom, six mid-slope, and six upper slope plots at Duff Creek are presented in Figure 5. Stream bottom plots were 1 X 1 chain plots that bordered the stream; upper slope plots were those at the end of each transect and from 7 to 12 chains from stream bottom; mid-slope plots were approximately halfway between stream bottom and upper slope. Similar data were not compiled for Forked Meadow Creek because of the gradually increasing topography from stream bottom and the varied microclimate caused by interspersed streamlets, meadows, and varied slope; by contrast, topography at Duff Creek rose abruptly and consistently from stream bottom to upper slope on both sides of the stream.

Canker incidence in all tree diameter classes was highest at the stream bottom plots. Eighty to one hundred percent of the sugar pines less than 12 inches dbh were infected. However, trees on upper slope plots were also infected, with infection ranging from 35% (6 of 17 trees) of the seedlings to 11% (1 of 9 trees) of the pole-sized trees.

Canker Incidence, by Year of Wood Infected. Cankers -- 259 at Forked Meadow and 71 at Duff Creek -- were aged in order to determine when infection occurred. Results are presented in Figure 6. As expected, the greatest number of infections occurred in 1976, a year favorable for rust infection throughout the more northern portions of the State. Although 1976 was a peak year, infection occurred every year from 1972 through 1979, even during the drought years of 1977 and 1978. These data, along with the incidence data of cankers away from stream bottoms, indicate that the climate of the Dinkey Creek area is favorable for rust infections most years. The planting of non rust-resistant sugar pine should be avoided in this high hazard area.

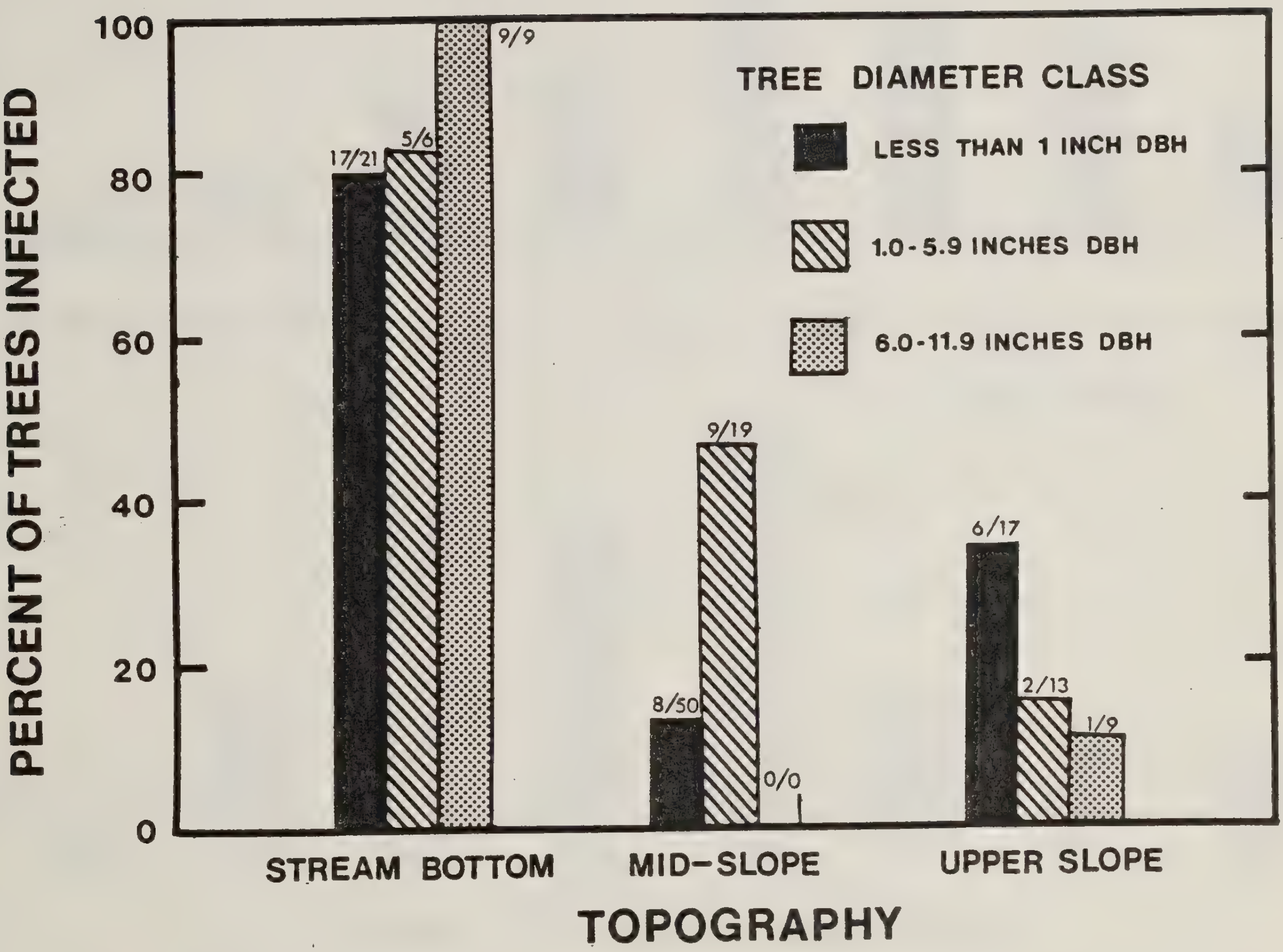

FIGURE 5. Blister rust canker incidence, by tree diameter class, at stream bottom, mid-slope, and upper slope plots at Duff Creek. The numbers above each bar are the number of trees infected/total number of trees.

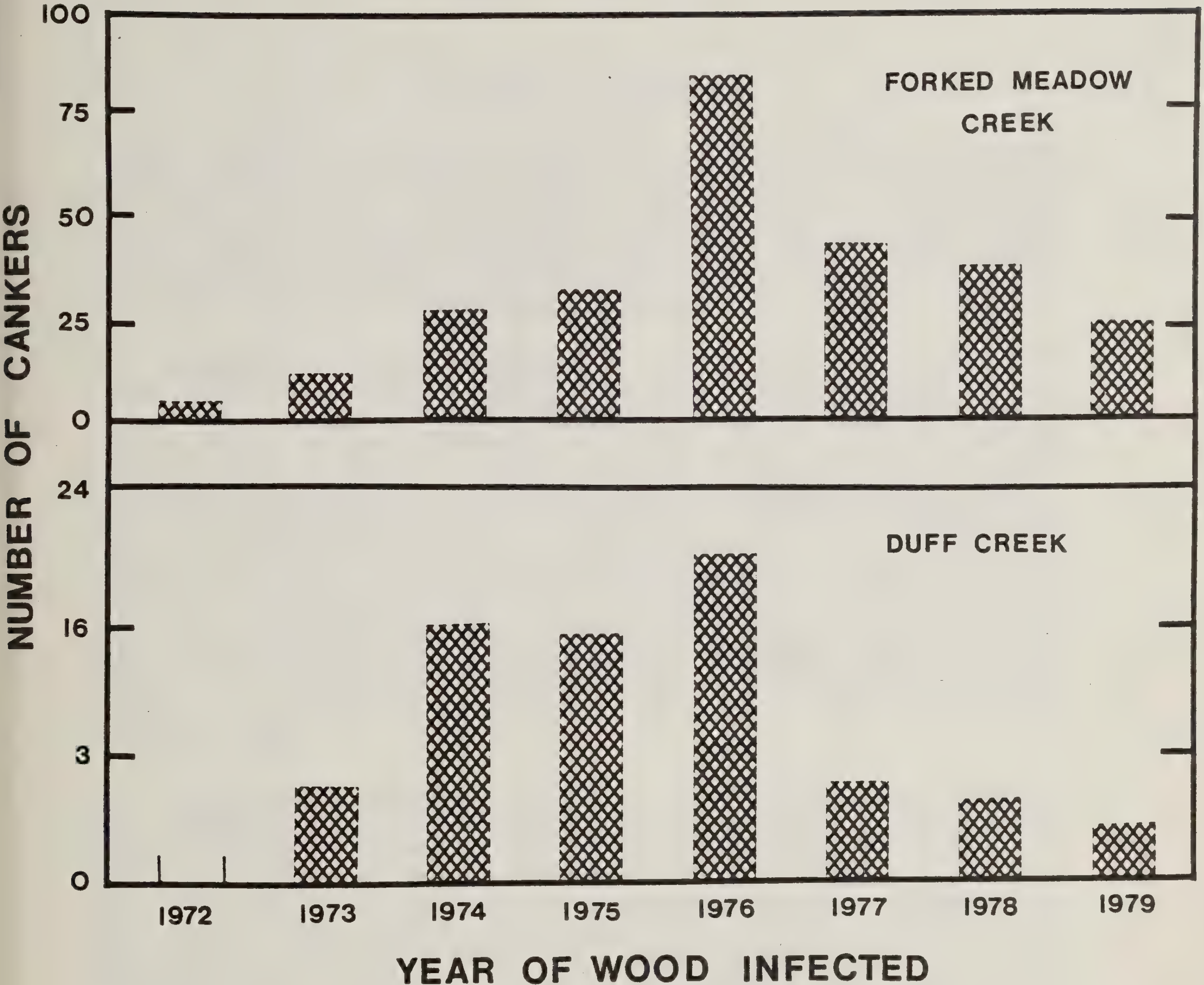

FIGURE 6. Blister rust canker incidence, by year of wood infected, at Forked Meadow Creek and Duff Creek on the Sierra National Forest.

MANAGEMENT ALTERNATIVES

Various strategies are available to the resource manager to reduce or mitigate current and potential impacts of white pine blister rust on the sugar pine resource. The presence of the disease, or potential for disease, does not preclude the management of sugar pine to meet recreational, esthetic, or wood production objectives. The following management alternatives are approaches which are available to the Forest to be part of an integrated pest management program.

1. No Change in Present Management. Blister rust will continue to spread to uninfected sugar pines in the Dinkey Creek and Soquel Meadow areas. The spread and intensification in the Dinkey Creek area will be partly limited by the elimination of hosts because of the Dinkey Dam Project. The disease will likely intensify in areas already infested, resulting in accelerated loss of seedling and sapling-size sugar pines. New rust cankers will continue to develop sporadically in the lower crowns of larger trees during favorable rust-years until shading and self-pruning of the lower 16 feet of the crown occurs. Sugar pine will continue to reproduce naturally in infested areas, but the amount of sugar pine in the future mixed conifer forest will decrease to levels which may not be adequate to maintain sugar pine as a significant component. The disease will spread to non rust-resistant sugar pines planted in areas currently infested, and losses unacceptable to the Forest may occur.

2. Sanitation/Precommercial Thinnings. Sugar pines with nonprunable bole cankers or with branch cankers within 4 inches of the bole are lethally infected and should be removed in sanitation thinnings or in conjunction with regularly scheduled thinnings. Removal of infected trees will not reduce the risk of leave trees becoming infected, but would remove non-productive competing trees and would possibly release those trees with a better chance of reaching merchantable size. Only uninfected trees should be considered as candidate leave trees during precommercial thinnings. These leave trees may subsequently become infected, but are likely to reach commercial size before cankers kill them.

3. Pruning. Most blister rust infections occur within 16 feet of the ground because of favorable microclimatic conditions. Pruning of all lower branches removes the needle-bearing surface of the tree that is most vulnerable to infection. Non-lethally infected trees (those without bole cankers in the lower 16 feet of the bole and those without branch cankers within 4 inches of the bole) could be pruned of all branches from the ground up to about 16 feet on larger trees and pruned to leave a 30% live crown ratio on smaller trees. Pruning of branch cankers will prevent the fungus from reaching the bole and killing the tree. This will reduce the mortality which will result from these current branch and bole cankers. The pruning of selected, lightly-infected sugar pines during precommercial thinning may allow a stand to reach merchantable size.

Pruning is expensive and its practical use as a control measure may be limited by economic considerations. Pruning may not be applicable in the heavily-infested stands in the Dinkey Creek area because of the lack of economic justification. Furthermore, pruning is no guarantee that a tree will not subsequently become lethally infected.

4. Regeneration. The presence of the rust, or its potential for occurrence in parts of the Forest not now infested, will not completely eliminate sugar pine as a component of the mixed conifer forest. Forest sites vary greatly in suitability for blister rust occurrence and intensification. The most useful indicator of future rust potential for a particular site is the level of rust that is currently present. In addition, the rust potential, or rust hazard, of a particular site is determined by 1) the topography, which influences the microclimatic conditions present, and by 2) the presence or absence of the hosts, sugar pine and *Ribes*.

Three levels of rust hazard -- low, moderate, and high -- can be distinguished. Low hazard sites are those where either sugar pine, *Ribes*, or both are absent and where the environment is generally unfavorable for infection of the host by the fungus. Unfavorable environments would include dry mid-slope or ridge top areas away from the influence of stream bottoms or wet meadows. Sugar pines could be planted on low hazard sites with minimal risk of subsequent infection. However, site preparation and planting may so alter the site that its hazard rating may change.

High hazard sites are those where blister rust is currently present on sugar pines and/or *Ribes* and where climatic conditions are favorable for rust incidence, as in moist, stream bottom sites. Sugar pines susceptible to the disease should not be planted in the Dinkey Creek area or other areas where blister rust is now present. Rust infections will occur sporadically on these high hazard sites during favorable rust years. Rust resistant sugar pines could be planted with little risk of infection.

Moderate hazard sites possess a wide gradation of characteristics, such as cool, moist sites where sugar pines and *Ribes* are not now infected, or mid-to-upper slope sites where rust is present, but at low levels. Management strategies for regenerating sugar pine should be developed on the basis of site characteristics and District or Forest objectives. Strategies on moderate hazard sites take into account the potential risk in managing sugar pine, and include: planting a mix of species rather than pure sugar pine, increasing stocking levels to minimize potential loss, reducing brush competition, utilizing rust-resistant stock if available, and increasing surveillance for the disease.

Before sugar pine is planted in any area on the Forest, the area should be thoroughly scouted for blister rust infection levels on natural sugar pines in the vicinity, or the Forest should request a biological evaluation for rust potential from FPM. Existing sugar pine plantations on

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the Forest should be inspected annually for the presence of blister rust and an evaluation requested from Forest Pest Management if assistance is needed. Recognition of the disease can be difficult. The Forest or the Districts should request training on surveillance from the Forest Pest Management Staff.

5. Integrate Treatments. Alternatives 2, 3 and 4 are not mutually exclusive. They can be used separately or in combination in various portions of the Forest to produce the results needed to meet stand objectives. Current sugar pine management practices can be continued on low hazard sites with little risk of blister rust impact. Some losses of sugar pines on high hazard sites are to be expected. These losses can be minimized by removing infected trees during sanitation and precommercial thinnings, by pruning infected branches, and by encouraging regeneration of species other than sugar pine. The impact of the disease on moderate hazard sites should be minimal if the potential for future rust impact is considered in management plans and objectives. More importantly, stands must be monitored aggressively for blister rust incidence to ensure that they can be treated before they become so diseased that they must be regenerated.

APPENDIX

A. TREE DIAMETER CLASS

The following six classes of tree dbh (diameter at breast height) ranges were designated:

DBH CLASS	DBH RANGE	
1	< 1.0"	seedlings
2	1.0 - 5.9"	saplings
3	6.0 - 11.9"	poles
4	12.0 - 17.9"	small sawtimber
5	18.0 - 25.9"	sawtimber
6	26.0" +	large sawtimber

B. CANKER CLASS

The following six classes of rust cankers, based on the position of the cankers in the tree, were designated:

1. Prunable bole canker: At a height 16 feet or less from the ground, and in the upper one third of live crown.

2. Nonprunable bole canker: At a height greater than 16 feet from the ground and/or in the lower two thirds live crown.

3. Nonlethal branch canker: Closest canker margin occurs 24 inches or more from the main bole.

4. Lethal prunable branch canker: Closest canker margin occurs between 4 and 24 inches from the main bole; the canker occurs in the lower two-thirds of the live crown and occurs 16 feet or less from the ground.

5. Lethal nonprunable branch canker: Canker occurs between 4 and 24 inches from the main bole; the canker occurs in the upper one-third live crown, and/or greater than 16 feet in height from the ground.

6. Lethal branch canker: Closest margin occurs within 4 inches of the main bole.

THE FOREST SERVICE OF THE U.S. DEPARTMENT OF AGRICULTURE is dedicated to the principle of multiple use management of the Nation's forest resources for sustained yields of wood, water, forage, wildlife, and recreation. Through management of the National Forests and National Grasslands, cooperation with the States and private forest owners, and forestry research, it strives—as directed by Congress—to provide increasingly greater service to a growing Nation.

THE GOAL OF FOREST PEST MANAGEMENT is to reduce pest-caused damage and losses on all forests and rangelands to levels commensurate with management objectives. The Forest Pest Management Staff provides leadership to forest land owners in dealing with pest problems effectively, while minimizing adverse effects on man and his environment.